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(19)(CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Ankle Joint Spring Element for Artificial Legs and Artificial Foot

(72) Schneider-Nieskens, Reinhold - Germany (Federal Republic of) ;

(71) IPOS GmbH & Co. KG - Germany (Federal Republic of) ;

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ABSTRACT OF THE DISCLOSURE

Ankle joint spring element for artificial legs and artificial foot.

In order to achieve a movement of the foot along the lines of a prosupination about the longitudinal axis of the foot, the ankle joint spring member provided with a reinforcing member (10) is comprised of a channel section (16), whose respective legs are elastically movable when subjected to a load so that an artificial foot possessing a function mechanism corresponding to the natural coordinated movements is obtained (Fig.1).

Ankle joint spring element for artificial legs and artificial foot.

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BACKGROUND OF THE INVENTION

The present invention relates to an ankle joint spring element for artificial legs, more particularly to a molded foamed plastic foot part provided with a metallic reinforcing member.

The invention further relates to an artificial foot for an artificial leg of a molded foamed plastic foot part provided with a plate-like metallic reinforcing member embedded in its sole region which, within the region of the ball of the foot, is constructed with a ball-like proceeding bend for assisting the rolling function of the foot and with a - serving in each case as an elastically yielding or giving shock absorbing or cushioning means - a forefoot core and a function core consisting of a tab disposed within the heel region, in which case the function core and the reinforcing member are rigidly interconnected and the reinforcing member is comprised of one or several approximately equally long, superposed leaf springs which are configured so as to conform to the rolling profile of the foot.

It has been known for a long time to employ foamed polyurethane plastic as material for an artificial foot which possesses the advantage of having a low weight. As proposed by way of example in the US-A-3,335,428, the foot part of an artificial leg may also be formed of an elastic plastic possessing a different hardness.

Moreover, from the DE-C-354 246, an artificial foot is known in which, within the region of the sole, a metal bar is embedded. This artificial foot is intended to make it possible for a leg or foot amputee to take long strides since this taking of long strides causes the oblique rearward displacement of

the lower leg, thus the resilience of the heel of the foot resting upon the ground with its entire undersurface. In addition, it is intended to cause the easy restraightening up of the lower leg without the same exceeding the vertical position, while the shifting of the weight of the body in the forward direction and the raising of the heel is intended to be rendered possible by the normal resilience of the metatarsus and the toe portion of the artificial foot. The resilience or yieldingness is to be achieved by the embedding of a spring plate that passes through the sole and the heel portion. In order to now be able to bring about the projection of the lower leg obliquely toward the rear, this known embodiment of an artificial foot provides a connection between the rigid lower leg and the spring plate, in which the lower leg moves from its upright position toward the rear in the manner of a rocker and, when the weight of the body is shifted, once more moves forwardly back into the former. This rocking motion is effected in that the cuneiformly tapering, rigid lower leg is seated in a saddle, the one obliquity of which is formed by the instep of the artificial foot and whose counter-obliquity is formed by a bifurcation of the spring plate. For the further shock absorption, a compressible wedge-shaped pad, e.g. of soft rubber, is located between the bifurcation and the actual spring plate. In order to avoid an undesirable noise being produced when the front wedge surface of the lower leg impinges upon the foot, the forefoot or metatarsus is comprised of a pliant or readily compressible, at any rate sound-deadening material, preferably felt. Also the supporting area of the lower leg is covered with a cap of this material. In this artificial foot, the bifurcation of the spring plate is rigidly connected with the rear wedge-shaped area of the lower leg.

However, in this case the bifurcation is not sharply bent aside since a rocking or swinging motion is strived for. That is why the bifurcation is mounted on the plate so as to glide with its knee. Consequently, in this known artificial foot a steel spring possessing springable properties is inserted which extends into the forefoot. However, in this case, the important differences in elasticity between metatarsus and the forefoot have not been taken into account from a constructional point of view. Moreover, the steel spring employed here does not make a natural rolling possible; also the connection problems between the different materials in the elastic area have not been constructionally solved.

Furthermore, from the DE-C-361 972, an artificial foot provided with a longitudinal spring element consisting of several reciprocally stepped leaf springs, whose leaf springs, with their rearward ends, are secured to the underside of a rigid block forming the rear foot portion, but separated from the sole by an intermediate layer, while the front spring ectremities carried downwardly at a suitable double angle, press directly upon the sole that is expediently covered with a protective sheet.

In an artificial foot for artificial legs known from the US-A-2,556,525, in an external foamed plastic molded foot part, a stiff but flexible plastic portion is embedded which extends over the entire length of the foot, in which case, in this stiff but flexible plastic part, a metal insert of spring steel is embedded. Even though an internal, partially flexible plastic part with a metal insert of spring steel is employed in this known artificial foot, it is not possible in this artificial foot to lay the rolling function onto the jarring or jolting line predetermined by nature. Despite the use of a flexible plastic part and of a metal insert of

spring steel, an adequate mobility in the metatarsophalangeal articulation, as exists in nature, is not possible.

In the DE-A-22 37 758, an ankle joint that is movable everywhere for tubular skeleton artificial limbs is proposed which, on an axis screwed into a carrier element, possesses a ball-and-socket joint, upon which an eyebolt is pressed which, in a press fit on a commercially obtainable ball-and-socket joint, receives the swivelable eye bolt, whose shank, while guided glidingly and flexibly in a ball-and-socket joint, carries a closing plate at the end which, fitted in the front and in the rear with buffer elements, controls the limitation of movement.

In order to provide an artificial foot for artificial legs having a rolling resistance predetermined over a long period of time and a buckling possibility in the metatarsophalangeal articulation, an artificial foot is proposed in the DE-C-23 41 887, in which the forefoot elasticity is ensured by the insertion of a homogeneous elastomer, that is to say, an elastic recovery capacity in the forefoot is taken into consideration which went beyond padding effects formed until that time. It has also already been proposed to make use of a reinforcing member of two approximately equally long, superposed leaf springs which are configured so as to correspond to the rolling profile of the foot.

It is the technical problem of the present invention to develop further the ankle joint spring element stated in the beginning in such a way that it permits a movement of the foot along the lines of a prosupination about the longitudinal axis of the foot. It is furthermore the technical problem of the present invention to develop further an artificial foot of the known type in such a way that a function mechanism is provided which corresponds to the natural coordinated movement.

SUMMARY OF THE INVENTION

The technical problem of the invention is resolved by the ankle joint spring element described in the Claim 1 which possesses a U-shaped outline, whose respective legs, when subjected to a load, can be moved elastically toward each other. The advantage of this embodiment consists in that a material-saving section can be employed and the manufacturing costs thus reduced to a minimum.

Further developments of the ankle joint spring element are described in the Claims 2 through 9. It is thus provided in order that the elasticity is increased that the running out ends of the channel section, preferably with the exception of the subareas required for the attachment to an accommodation space for a leg connection portion, taper in their material thickness in the direction of the free end. By preference, the ends of the legs are constructed so as to be thickened, in a special embodiment provided with bead-like thickened portions which are formed over the entire width. With regard to an attachment, e.g. with the aid of a bolt, these thickened portions supply an adequate mounting or guidance without the risk of material fractures or elastic deformations existing.

According to a further embodiment, the ends of the legs are in each case provided with at least one, preferably two, drilled holes disposed in a side-by-side arrangement. Owing to the superposed drilled holes of different legs, one bolt can be inserted at a time.

A further improvement with respect to the prosupination about the longitudinal axis of the foot while at the same time making possible a rotation about the longitudinal axis of the leg results when the channel section is provided with recesses that extend at least over a part of its longitudinal axis. These recesses consist preferably of elongated slots,

which, in a further improvement, extend continuously from the first leg across the base up to the second leg of the channel section.

An adequate support, while at the same time providing an adequate elasticity is achieved when the width of the channel section amounts to approximately 0.4 to 0.6 times the length. By preference the channel section is, when regarded in a view from the top, substantially rectangular. If a titanium-aluminum alloy is employed as material for the channel section, it is possible to construct the ankle joint spring element so as to possess a low weight. The previously described ankle joint spring element is preferably incorporated into an artificial foot of the type described in the beginning, in which it serves as a connection between a reinforcing member and an accommodation space of a leg connection portion which is connected to a leg of the channel section. The leaf springs or spring used in the artificial foot consist(s) of carbon fiber or of titanium or of a titanium alloy.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiment examples of the invention are illustrated in the drawings. Thus

F i g. 1 shows a perspective view of an ankle joint spring element, and

F i g. 2 shows a cross-section through an artificial foot.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The reinforcing member 10 depicted in Fig. 1 possesses a bend 11 within the region of the ball of the foot 12 of the artificial foot which is configured in conformity with the rolling profile of the foot. The reinforcing member 10 is embedded in a forefoot core 13 as well as in a tab 14

located in the heel region. The function c re comprising the components 10,13 and 14 is surrounded by a molded foamed plastic part 15 which, in its rearward portion, has a hollow space for accommodating articulations or fastening elements. The downwardly directedshoulder 11 is constructed in such a way that the rolling function is laid onto the front trisection line (metatarsophalangeal line). In this connection, a forefoot core 13 comprised of an elastomer is vulcanized onto the bend 11 of the reinforcing member 10, which, in its lower terminating line, corresponds to the external configuration of the ball of the foot. Owing to the foam-enveloped structure, the forefoot core 13 is completely resistant to aging so that the rolling resistance is inalterably predeterminable over a protracted period of time. The tab 14 is attached by vulcanization in the heel portion in a corresponding fashion.

At its rear end, the reinforcing member 10 constructed in the form of a leaf spring is connected to the ankle joint spring element 16 according to the invention in the form of a channel section. The base of the channel section points in the direction of the toes or the free ends of the channel section legs point toward the heel. The channel section 16, which is depicted in greater detail in Fig. 2, possesses thickened portions 17 which extend across the entire width b. In these thickened portions 17, drilled holes 18 or 19 disposed in a side-by-side arrangement are to be found in said thickened portions 17, which are arranged superposedly in such a fashion that bolts 20 which can be gathered from Fig.1, can be inserted through respective superposed drilled holes of the two legs. This bolt 20 is screwed together with an accommodation space of a leg connection part or is otherwise rigidly connected. The channel section 16 is further provided with slots 21 that reach as far as into the area of

the thickened portions 17 which extend continuously from the one free leg across the base up to the end of the other free leg. Thse slots, here two slots 21, are carried parallel to each other and parallel to the non-depicted longitudinal axis. The channel section is constructed in such a way that, if possible, both legs but at least one leg, exhibit(s) a reduction in thickness 22 toward the free end, whereby the elasticity of the free leg is increased in the area. As can be gathered from Fig.1, between the free legs of the channel section 16, soft polyurethane foam 23 is inserted. The leaf spring serving as reinforcing member 10 is constructed of carbon fiber or titanium.

The depicted artificial foot possesses the advantage that it makes smooth movements possible which merge into each other. For different foot sizes it is possible in each case to use different channel section spring systems, in which connection the dimensioning of the channel sections permits a resistance which is matched precisely with the requirements of the movement. Over and above that, specific flexibilities enter into the construction via the elaongated slots 21.

WHAT IS CLAIMED IS:

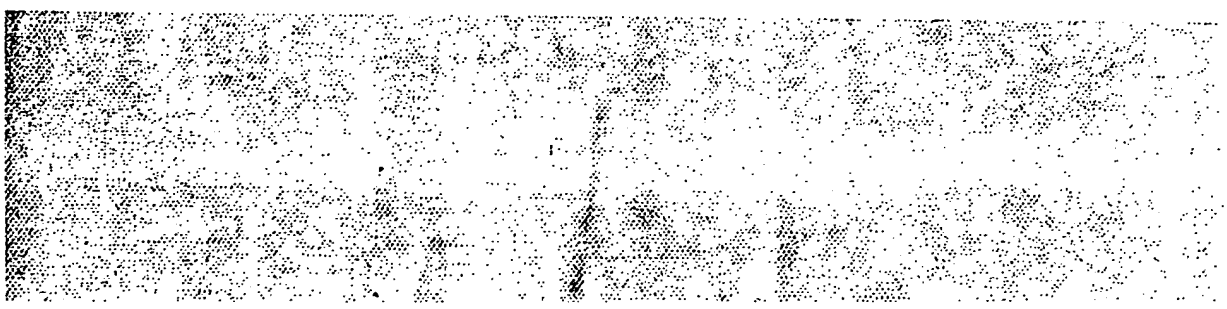
1. Ankle joint spring element for artificial legs, more particularly for a molded foamed plastic foot part provided with a metallic reinforcing member (10), characterized by a channel section (16) whose respective legs, when subjected to a load, are movable toward each other.

2. Ankle joint spring element according to Claim 1, characterized in that the running out ends, preferably with the exception of the subareas required for the attachment to an accommodation space of a leg connection part, taper in their material thickness toward the free end.

3. Ankle joint spring element according to either Claim 1 or 2, characterized in that the ends of the legs possess thickened portions (17) which are preferably constructed on the insides across the entire width (b).

4. Ankle joint spring element according to any of Claims 1 through 3, characterized in that the ends of the legs possess in each case one, preferably two, drilled holes (18,19) disposed in a side-by-side arrangement for a single bolt (20) at a time to be passed through two superposed drilled holes.

5. Ankle joint spring element according to any of Claims 1 through 4, characterized in that the channel section (16) possesses recesses (21) extending at least over a part of its longitudinal axis.



6. Ankle joint spring element according to Claim 5, characterized in that the recesses are elongated slots (21) which preferably extend continuously from the first leg to the second leg.

7. Ankle joint spring element according to any of Claims 1 through 6, characterized in that the width (b) of the channel section (16) is approximately 0.4 to 0.6 times the length.

8. Ankle joint spring element according to any of Claims 1 through 7, characterized in that the channel section (16), when regarded in a view from the top, is substantially rectangular.

9. Ankle joint spring element according to any of Claims 1 through 8, characterized in that the channel section is comprised of a Ti-Al alloy.

10. Artificial foot for an artificial leg of a molded foamed plastic foot part provided with a plate-like metallic reinforcing member embedded in its sole region which, in the region of the ball of the foot, is provided with a ball of the foot-like proceeding bend for assisting in the foot rolling function and having - serving in each case as an elastically yielding cushioning means - a forefoot core and a function core consisting of a tab disposed in the region of the heel, in which case the function core and the reinforcing member are rigidly interconnected and the reinforcing member is comprised of one or several approximately equally long superposed leaf spring(s) which are configured so as to conform to the rolling profile of the foot,

characterized in that
the reinforcing member is connected to a leg of a channel section which is elastically springable when subjected to a load and the other leg is connected to the accommodation space of a leg connection part.

11. Artificial foot according to Claim 10,
characterized in that
the leaf spring(s) is/are comprised of carbon fiber or titanium or of titanium alloy.

12. Artificial foot accoding to either Claim 10 or 11,
characterized in that
the interspace between the free leg of the channel section (16) is filled with a soft polyurethane foam.

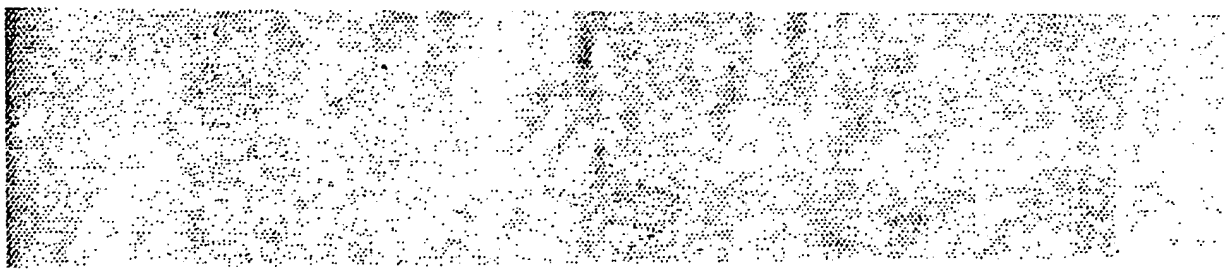


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Fig. 1

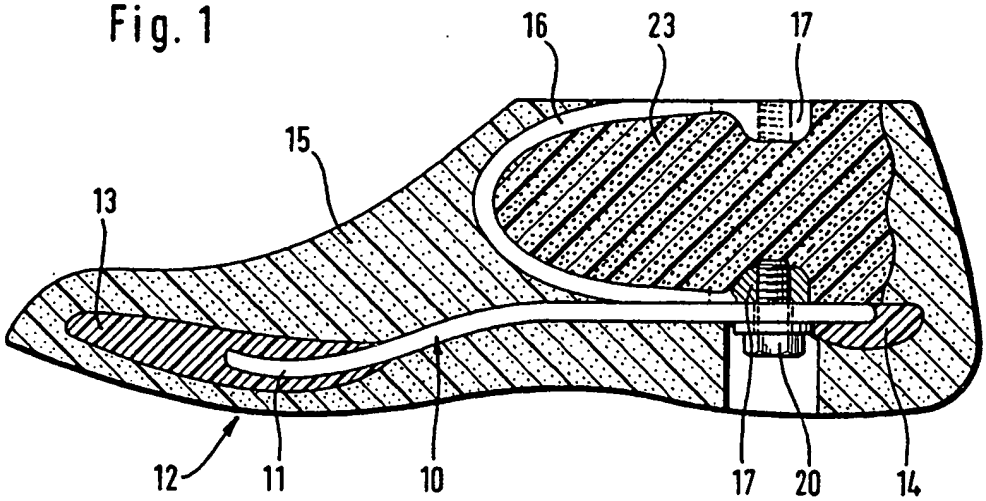

Fig. 2